EXPLORATIONS

Activity 3

Energy from Foods — Part II

Objectives

- To understand how electrochemical cells work
- To determine the factors that affect the voltage of an electrochemical cell

Materials

- TI-73
- Unit-to-unit cable
- CBL 2™
- Voltage sensor
- Fruits/vegetables
- Zinc strip
- Copper strip
- Plastic knife to cut slits
- Paper towels
- Data Collection and Analysis pages (p. 27 – 29)

In this activity you will

- Vary the distance between the electrodes on a fruit or vegetable.
- Use the CBL 2™ with the voltage sensor to measure the electrical energy produced at each distance.

Problem

Will varying the distance between the electrodes on a fruit or vegetable change the voltage?

Hypothesis

Before testing, complete the **Hypothesis** and **Experimental Design** sections on the **Data Collection and Analysis** page to predict what happens to the voltage.

Procedure: Collecting the Data

1. Cut slits in one fruit or vegetable ranging from 1 to 6 cm apart.
2. Place a zinc strip in one slit and a copper strip into the other slit.
3. Plug the voltage sensor into Channel 1 (**CH 1**) on the CBL 2.
4. Start the DATAMATE program.
5. The Main Screen is displayed.
6. Select **1:SETUP**.

7. Select **MODE** by pressing ▼ to highlight **MODE** and pressing ENTER. Then select **3:EVENTS WITH ENTRY**.
8. Select **1:OK** to return to the Main Screen.
9. Attach the positive lead to the copper strip and the negative lead to the zinc strip.
10. When you are ready to begin, select **2:START**. The screen displays **PRESS ENTER TO COLLECT OR STO TO STOP**.
11. When the voltage reading is steady, press ENTER.
12. The program asks you to enter a value. This value is the number for the distance between the electrodes, NOT the voltage reading. Type the number for this distance (for example, if this is the first distance, type **1**) and press ENTER. The program returns to the data collection screen, ready for the next distance between the electrodes.
13. Repeat steps 9 through 12 for each distance, using the number for the distance when the program asks for a value after you have the voltage. After you enter the first distance number, the last number you used is displayed at the bottom of the screen.
14. After you have collected the voltage reading for the last sample, press STO▶. A scatter plot is displayed showing the voltage reading for all of the samples. Use ▶ and ◀ to move to each data point and record the values in the table on the **Data Collection and Analysis** page.
15. Repeat steps 9 through 14 two more times for a total of three trials.
16. To exit from the DATAMATE program, press ENTER to return to the Main Screen. Select **6:QUIT** and press ENTER.

Extension

Repeat this activity, testing all possible combinations of copper (Cu), zinc (Zn), magnesium (Mg), and carbon (C) strips used as electrodes in fruits or vegetables. Use the CBL 2™ with the TI-73 and the voltage sensor to measure the electrical energy produced with different electrodes.

Data Collection and Analysis

Name _____

Date _____

Activity 3: Energy from Foods — Part II

Problem

Will varying the distance between the electrodes on a fruit or vegetable change the voltage?

Hypothesis

If the distance increases, the voltage will _____ .

Experimental Design

1. Independent Variable: _____
2. Dependent Variable: _____
3. Constants: _____

   _____

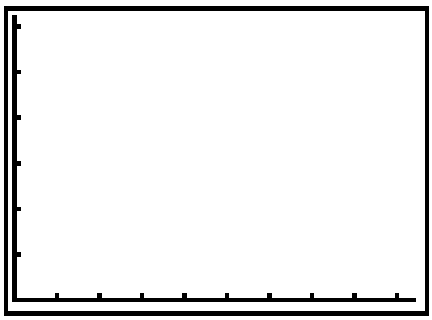
   _____
4. Number of Trials: _____

Data Collection

1. After you test the different distances, use the displayed scatter plot to fill in the voltages from Trial 1. Repeat the tests two more times and fill in the results for Trial 2 and Trial 3. Then use the calculator to find the mean of the voltage at each distance.

Distance (cm)	**Trial 1** (Volts)	**Trial 2** (Volts)	**Trial 3** (Volts)	**Mean** (Volts)

2. Sketch the scatter plot of voltage versus distance or print the graph on the computer and attach it to this page. Plot distance on the *x*-axis and voltage on the *y*-axis.



3. Is there a relationship between the variables?

_____

_____

4. Find the line of best fit for this data with your calculator.

_____

_____

Data Analysis

1. How is the distance between electrodes and voltage related?

   There is a (positive / negative / no) correlation between distance and voltage.

2. Predict what the voltage would be if you doubled the distance. Set up a table of your results on the TI-73 and then use the table to calculate the additional values to check your prediction. Record the values below.

   Independent Variable: _____ Dependent Variable: _____

X	Y1

3. Explain how resistance might be related to your voltage results.

_____

_____

_____

Conclusion

As distance between electrodes increases, the voltage _____

because _____ .

Teacher Notes

Activity 3

Energy from Foods — Part II

Objectives

- To understand how electrochemical cells work
- To determine the factors that affect the voltage of an electrochemical cell

NSES Standards

- Physical Science: Transfer of energy
- Science as Inquiry: Abilities necessary to do scientific inquiry

Preparation

- Students can bring in fruits and vegetables to test. Plan to have a variety of four to six food items at each lab station.
- Provide small plastic knives and measuring tapes for cutting the slits.
- Copper and zinc 2" strips can be cut from sheet metal by the shop teacher in your school. In a pinch, pre-1982 pennies (except steel) can be used for copper and zinc washers can be used instead of zinc strips.
- Alligator clips may be used to save wear on the voltage sensor leads that can break off if handled roughly.
- Paper towels are a must to keep the juice from the fruits away from the CBL 2™ equipment.

Management

- Ask students to sketch the lab setup before starting the lab and label the sketch with key terms. Students learn vocabulary in context and seem less confused by the procedure.
- Explain that the fruits and vegetables will create one wet cell as opposed to a battery that is made from a series of cells. An example of a dry cell is a AAA; a 9 volt is a true battery as it contains six 1.5 volt cells. All 1.5 volt dry cells contain the same voltage, regardless of size.
- Assign these student jobs for this lab:
  - Materials/setup person (sets up samples, sensor)
  - Tech person (operates CBL 2 and TI-73)
  - Data recorder (reads voltage readings from the CBL 2 at each collection interval)
  - Runner (brings CBL 2 and TI-73 to the computer to print out graphs with TI-GRAPH LINK™ or TI™ Connect and brings **Data Collection and Analysis** pages to the teacher)

- Clear covered plastic shoeboxes will hold the CBL 2™, voltage sensors, electrodes, and other equipment neatly at each station.
- Students can record voltage readings as they are displayed on the TI-73 in their lab journals. This keeps them engaged throughout the data collection period and if they lose their data/graph later, they can still write up their lab report. Students can also access the data in the TI-73 lists after data collection. You can send the lists to all students' calculators using APPS **1:Link**.

  a. Press APPS.

  b. Press ENTER to select **1:Link.**

  c. Select **4:List** and press ENTER.

  d. Press ▼ to move the ▶ beside the list you wish to send. Press ENTER.

  e. Repeat step **d** for each list you wish to send.

  f. Set the receiving unit by pressing APPS ENTER ▶ to select **RECEIVE**. Press ENTER. **Waiting…** displays on the TI-73 screen.

  g. On the sending unit, press ▶ to select **TRANSMIT** and press ENTER.

  For more permanent storage of data, use TI-GRAPH LINK™ or TI™ Connect to save the lists in a computer folder.
- Students can assess each other using a teamwork rubric after the lab. Provide a checklist of positive and negative behaviors. Copy these on quarter sheets of paper.

Data Analysis

- Students can print their graphs on the computer using TI-GRAPH LINK or TI Connect software and cable. They can also paste the graph into a word processing program. Students can then write their lab report/conclusion with the graph.
- In a one-computer classroom, a student from each lab station can use TI-GRAPH LINK or TI Connect to print copies of the graphs for each team member. Students then can incorporate these graphs in their lab reports.
- Middle school students are often learning initial graphing skills. Skills such as determining the scale for the axes and determining the quartiles are difficult for many. Plotting the data by hand is always an option in each lab and space has been provided for this on the **Data Collection and Analysis** page.
- Use **MODE** to round voltage data to the nearest thousandth. Increased resistance should cause voltage to decrease with distance but the difference is only in hundredths of a volt. Discuss sources of experimental error if there is a positive or no correlation.
- Since each group is getting only one value for each beverage, average all of their results and have the students record the results on the **Data Collection and Analysis** page.

Selected Answers

Experimental Design

1. Independent Variable: *distance between electrodes (cm)*
2. Dependent Variable: *voltage (volts).*
3. Constants: *fruit/vegetable used, electrodes, same CBL 2 and voltage sensor*.
4. Number of Trials: *3*

Conclusion

As distance between electrodes increases, the voltage will *decrease* because *resistance increases*.

***Note**: Voltage differences will be small. A CBL 2 can detect fine differences that a pH meter cannot.*